IV. CONCLUSION

Q.32 Please summarize your rebuttal to Mr. Gillan's position.

A.32 The issue before us is not whether Ameritech Illinois will provide UNE-P, but rather, who shall have the responsibility of combining UNE-Ps where combinations do not now exist. I believe that the CLECs have that obligation. The activity of combining UNEs is an activity that the CLECs are capable of performing. And there is no reason that ILECs should, as a matter of policy, bear the responsibility of combining these elements on behalf of CLECs. Proper assignment of responsibility helps ensure that those CLECs that have chosen not to use the UNE-P, but that instead have elected to invest in network infrastructure, are not harmed by a rule that helps those that invest little or nothing in the network.

In contrast, Mr. Gillan simply asserts that CLECs (in particular, UNE-P-based CLECs) having to assemble their own combinations would face a "difficulty." The "difficulty" threshold is nowhere defined, except perhaps in Mr. Gillan's eye. Mr. Gillan fails to quantify the "difficulties" that he envisions. He also fails to account for the harmful effects that seeking regulatory intervention, where none is needed, would have on the longer-run development of robust competition, including the competitive inroads and efforts made by those who invest in network infrastructure. Imposing this unjustified obligation on Ameritech Illinois is poor economics and shortsighted public policy.

Q.33 Please summarize your rebuttal of Dr. Liu's testimony.

A.33 Dr. Liu misunderstands the "single price equivalent" generated by the ARPSM. The "single price equivalent" is designed to summarize in a single calculated price the outcome of a competitive process that, due to the technological and economic characteristics of the product, results in the equipment vendors charging Ameritech Illinois a two-tiered price structure, with different prices for growth and replacement lines. Because it would be inconsistent with the normal functioning of markets for Ameritech Illinois to charge different prices to its customers (CLECs) for growth and replacement lines, the two-tiered prices must be summarized or collapsed into a single price which preserves the competitive constraints that produced the prices in equilibrium. The single price equivalent does so by determining the average cost that Ameritech Illinois incurs on a per line basis under the two-tiered pricing structure. It is an average cost (specifically, a total element average cost)—not a marginal cost, as Dr. Liu erroneously concludes.

Q.34 Does this conclude your Surrebuttal Testimony?

A.34 Yes, it does.

Optimal Switch Pricing and Single Price Equivalency

by

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June 4, 2001

I. Introduction

SBC currently procures switching equipment from its vendors according to contractual arrangements that differ significantly from those which traditionally governed equipment procurement in the past. The current contractual arrangements have features that, first, make the traditional engineering-based methodology for determining switching costs invalid; second, include price schedules whose structure demands economic interpretation; and third, render necessary a new methodology for translating the contractual prices into TELRIC prices. The purpose of this paper is to address the latter two issues. I explain why the current contract price structure is rational and consistent with the economic structure of the market, and I derive the appropriate methodology for determining TELRIC prices from the contractual prices. The two goals are necessarily interrelated, because it is impossible to interpret the contractual price structure in order to properly determine TELRIC prices without understanding its economic basis.

In Section II of this paper, I provide a brief description of the relevant features of SBC's vendor contracts. Section III contains the key assumptions underlying the model, and provides the main results supporting the multi-tiered pricing structure as the unique equilibrium outcome in the market, and the sensitivity of the results to the demand structure. Section IV shows that there exists a single per-line price to which the vendor would be indifferent relative to the more complex multi-tiered price structure in the vendor contracts and demonstrates how to calculate that price. I further explain that this single price is the proper TELRIC price that would prevail if the entire network were replaced.

II. SBC's Vendor Contracts

SBC procures switching equipment from three vendors, with whom it has negotiated contracts. As used in this paper, the term "contract" means the set of prices and conditions currently in effect; since these terms and conditions evolve over time, a single vendor "contract" might consist of an original agreement, subsequent amendments, and/or updated price lists. The vendor contracts currently in effect describe the terms and conditions under which the vendors will provide switching equipment. In each of the contracts, the vendor provides switching facilities to SBC on a per-line basis. By the terms of the contracts, SBC buys switching equipment by paying a one-time price for each line that it demands. The line prices do not vary with year of purchase or the state in which the equipment is installed. However, they do vary on the basis of whether the lines are being cut over from retiring analog 1AESS switch (an "analog switch" or "1A") to a replacement digital switch (these lines are known as "cutover" or "replacement" lines), whether the lines are augmenting the capacity on an existing digital switch ("growth" lines), or whether the lines are installed on a brand-new digital switch—that is, one that is not replacing an existing switch ("new" lines). Note that all lines under the contracts are provided on digital switches.

One critical feature of SBC's current vendor contracts is that they are structured in such a way that SBC pays a higher per-line price for growth lines than it does for replacement lines or for new lines. Nevertheless, although the prices SBC pays to its vendors vary as described, it is irrelevant to the end-user whether the line being purchased is designated as a "replacement," "new," or "growth line." Hence, in a competitive market, a single retail price charged by SBC to its customers for a network access line would prevail in equilibrium, independent of whether the particular line was purchased from the vendor as a growth, new, or replacement line. This principle - that the price of a good does not depend on cost differences pertaining to one unit of the good relative to another - is commonly observed in competitive markets. For example, the price a customer pays for a six-pack of Coca-Cola does not depend on the bottling plant at which it was produced, though the costs of production might vary from one plant to another. Similarly, the price customers pay for a bottle of aspirin at the pharmacy does not depend on whether the particular bottle was delivered to the store via truck, rail, or air. These decisions are production-side choices that are transparent to the end-user.

By the same token, the retail price for telephone lines would not mirror the multiple-price structure of the vendor contracts. In particular, the retail price in a fully competitive market would reflect SBC's *marginal* cost of lines. The marginal cost of a line is the cost incurred as a result of increasing the number of lines by one. Hence, the marginal cost to SBC is probably best reflected in the cost of growth lines, because SBC is limited to the number of cutover (replacement) lines specified in the vendor contract and is limited to placing "new" lines where switches did not previously exist; but may buy as many growth lines as desired on any digital switch at the growth price.

Because the marginal cost of lines is simply the growth price stated in the vendor contracts, the marginal cost of a line to SBC is fairly straightforward to determine from the vendor contracts. Prices of unbundled elements are not, however, to be set on the basis of *marginal* cost but, rather, on the basis of Total Element Long Run Incremental Cost ("TELRIC"). The TELRIC concept does not refer to marginal costs, but to average incremental cost.

It is clear from examination of the prices in the current vendor contracts that the vendors' price differences between replacement and new lines on the one hand, and growth lines on the other, are not explained by differences in the vendors' cost structures. Indeed, if anything, one would expect the cost of installing growth lines on an existing switch to be *lower* than the cost of replacing a switch with a new one or installing an entirely new switch. In fact, the prices have the reverse pattern, with growth prices significantly exceeding either replacement or new-line prices, as I have indicated above. The simplest economic explanation for the price difference is described by the following train of economic logic. The vendors offer contracts in competition with each other, so the competition among the vendors constrains the vendors' profitability to some extent. Vendors offer contracts that compete aggressively on the price of replacement switches, knowing (as both buyer and seller do) that once the buyer is locked into a particular switch technology at a given wire center, the vendor will have the ability to extract higher prices for growth lines on the switch. The reason is that the vendor will have monopoly power over SBC for growth lines on any given switch, once the switch is installed. Hence, the vendors compete *ex ante* to provide the switch, but have monopoly power *ex post* over the ability to augment the switch with additional lines. The fact that the vendor will rationally extract higher prices for growth lines once the switch is installed is known in economics as "subgame perfection." Both parties (buyer and seller) know that prices must be subgame perfect, because it would not be rational for the vendor to fail to extract higher prices once the buyer is locked into the vendor's technology. Hence, vendors compete for business by driving *down* the replacement (and new line) prices, possibly even below their cost, in order to "make up for" the inevitably higher growth prices. This gives rise to the multi-part pricing structure for growth, replacement, and new lines. The individual prices for growth, new, and replacement lines will not align with their individual costs; but the discounted present value of the revenues expected by the vendor from the new, growth, and replacement prices must, *over all*, recover the costs anticipated by the vendor for providing the services in total. I demonstrate this phenomenon in my formal model. In particular, I demonstrate that the structure of the market (the *ex post* monopoly power together with the *ex ante* competition among the switch vendors) forces the multi-part pricing structure seen in the contracts. In addition, I demonstrate how to arrive at the proper TELRIC cost given the underlying economic framework of the vendor contracts.

There are three parts to the formal analysis. First, I develop a model, based on the characteristics of the switching equipment market, to analyze price competition in this market. I demonstrate that the equilibrium vendor contracts typically involve a different price for replacement than for growth lines. For the formal analysis, I abstract from the existence of "new" line prices. New lines play the same economic role in the model as do replacement lines. Hence, for simplicity, I model only the relationship between growth and replacement prices. The same qualitative relationship will hold between new and growth line prices. I comment in Section IV on the economic factors that can drive the difference between new and replacement prices themselves. In that section I also explicitly incorporate new prices into the formulas for calculating TELRIC prices under the theory.

Second, I show that if vendor contracts were not structured as they are, but rather contemplated only demand for replacement (or new) lines, the price for these lines would be higher than the replacement line price in the current vendor contracts. The vendors would simply not offer the lines at the replacement or new rate if they did not have the promise of earning the higher profits on the growth lines. I demonstrate the sensitivity of the vendor contracts to changes in the proportion of growth lines out of the total number of lines anticipated by the contracting parties. The prices are a continuous function of this proportion.

Third, given the results of this model, I derive the proper methodology for computing a Single Price Equivalency in accordance with the requirements of the TELRIC methodology. The TELRIC price is the price that would prevail if the vendors could have credibly negotiated with SBC for all replacement lines, all new lines, and all growth lines to be installed at one price, but satisfying the competitive constraints that actually exist in the market (that is, holding vendor profits constant).

III. Competitive Framework of the Switching Equipment Market

The model attempts to capture the structure inherent in the contracts between switch vendors and SBC. In particular, the model is constructed to capture the potential ex-post monopoly problems inherent in the vendor-buyer relationship, deriving from the technological constraints by which the local exchange carrier is locked into a given vendor's technology once an investment has been made with the particular vendor. There are three important assumptions in this model that drive the contract's structure.

> **Assumption 1:** Each vendor bids for the right to serve a particular wire center. Competition constrains the vendors' *ex ante* expected profits from the outcome of the bidding process to be π. I assume π is strictly less than monopoly profits.

We need not assume that competition drives the vendor's expected profits to zero, although zero profits equilibrium for the vendor is permitted in the model, and I consider this case specifically later in my analysis. In addition, for notational simplicity I have not differentiated π by vendor, but the vendors' *ex ante* equilibrium profits need not be the same.

> **Assumption 2:** Once a wire center has a given vendor's switch installed, all future growth in that office will build off of that switch. That is, it would not be optimal at a given location within the relevant range of prices for the LEC to install a new switch once a given digital switch is in place, nor can the growth modules from one vendor be used to add capacity to the switch of another vendor.

Given Assumptions 1 and 2, I do not explicitly model the competition between vendors. Instead, I model the game between a given vendor and the LEC, where the vendor's profits are constrained to be π. This is the dual problem to the competition problem. The model is structured as a three-stage game between the vendor and the local exchange carrier. Before the first stage the buyer announces its demand for replacement lines (which may be a function or may be a number) in a "request for proposals" (RFP). Typically, an RFP specifies a <u>number</u> of replacement lines to be bid on for each wire center, so I will follow this assumption, but it is not critical. Assume the RFP level of demand for a given wire center is N_R replacement lines. The three stages of the game are:

> **Stage 1:** Switch vendors offer prices for replacement and growth lines for a given wire center. If accepted, the contract would commit the vendor to installing N_R

replacement in period 0 and an unspecified number of growth lines in periods 1 through T.

Stage 2: The local exchange carrier, the buyer, chooses whether to accept or reject the offer.

If the buyer chooses to reject all vendors' offers, then the game ends. If the buyer chooses to accept a vendor's offer, then replacement lines are installed and the game continues to Stage 3, which takes place in periods t=1 through T.

Stage 3: In this stage, the vendor can renegotiate the contract prices for growth lines in subsequent periods.

Let ($C_{Ri}, C_{Gi},$) be the cost to vendor *i* of *replacing* switching facilities (denoted by a subscript "R") with new digital switches, per line, and installing *growth* capacity in existing switches (denoted by a subscript "G"), per line. That is, C_{Ri}, C_{Gi} are the average cost to vendor *i* of replacing and providing growth capabilities, respectively.

For the wire centers under consideration, there are a total of N_R lines already installed in the existing analog switches. The buyer would like to replace the analog switches with digital switches. It is anticipated that in the future there will be growth in demand, which will require additional lines to be added to the switches. Let P_R be the per-line price of cutting over new digital switches, and let N_{Gt} be the expected number of growth lines demanded in year t, which is a function of the relevant price P_G.

Because of the *ex post* market power retained by the vendor, we are interested in the subgame perfect equilibrium of this game. I solve this problem via backward induction, starting with the third stage subgame.

A. Third Stage

By Assumption 2, once a buyer has installed a digital switch of a given technology, (s)he is locked into the technology of that vendor. The vendor, then, is the sole supplier of growth lines for this particular switch. Once the buyer has purchased a switch, the vendor's problem for pricing the growth lines is:

$$\max_{N_G} \sum_{t=0}^{T} \{(P_G(N_{Gt}) - C_G) N_{Gt}\} \left(\frac{1}{1+r}\right)$$

Let N_G^* be the solution to this problem, where we assume the demand function to be the same in each period for simplicity, and let $\overline{P}_G^*$ be $P_G(N_G^*)$. That is, it is the *ex post* monopoly price of growth lines for a given vendor. Hence,

Lemma 1: $\overline{P}_G$ is the price that must prevail in the 3rd stage in equilibrium.

B. Second Stage

In the second stage, the buyer chooses which contract to accept, if any, for the wire center. The buyer's optimal strategy for each wire center is:

1. calculate the buyer's expected profits from every vendor's contract, given the outcome of the subgame in the 3rd stage (i.e., given Lemma 1),
2. select the highest expected profit contract, and
3. if the expected profit of that contract exceeds zero, accept it. Otherwise, accept no contract.

C. First Stage

In the first stage, I consider contracts of the form $\{P_R, P_G\}$. Vendors at this stage choose both the growth and replacement prices per line. Because the buyer is not locked into a technology from each supplier, the vendor is not a monopolist at this stage. This is consistent with Assumption 1 in our model, which constrains *ex ante* expected profits to be below monopoly profits.

Following from the definition of profit and Assumption 1, the vendor's profit function is,

$$Z(P_R, P_G) \equiv (P_R - C_R)N_R + \sum_{t=1}^{T}\{(P_G(N_{Gt}) - C_G)N_{Gt}\}\left(\frac{1}{1+r}\right)^t.$$

I require that the contract be subgame perfect, which implies that vendors in the first stage of the game and buyers in the second stage must internalize the equilibrium prices of the third stage.

Finally, I define the buyer's profit function as $B(P_R, P_G)$, and note that $B(\bullet,\bullet)$ is monotone decreasing in both of its arguments, by the standard properties of profit functions.

Proposition 1: The equilibrium, subgame perfect contract solves the following dual program:

Program 1

$$\max_{\{P_R, P_G\}} B(P_R, P_G)$$

s.t. (i) $P_G = \overline{P}_G$

(ii) $Z^* = \pi$,

where Z^* is the value of $Z(P_R, P_G)$ evaluated at the optimum, and $\overline{P}_G$ is the third stage equilibrium price, that is, the *ex post* monopoly price of growth lines defined in Lemma 1.

Proof: The contract is consistent with equilibrium by (ii). The contract is subgame perfect by (i) and Lemma 1.

Q.E.D.

Proposition 2: Let $\overline{P}_R$ be the monopoly price for replacement lines. Then, at the solution to Program 1,

(iii) $P_R < \overline{P}_R$.

Proof: By definition of $\overline{P}_R$, $P_R > \overline{P}_R$ is suboptimal (since the vendor would never price above monopoly price). Suppose that $P_R = \overline{P}_R$. It then follows from constraint (i) of Proposition 1 that the firm would earn monopoly profits overall, which violates assumption 1. The result then holds by monotonicity of B.

Q.E.D.

It is left for us to show that the subgame perfect equilibrium structure of prices is consistent with the observation that replacement prices are below growth prices. I look at two cases:

Case 1: I first assume that the demand in every period 1 through T is the same as the demand in the first period, and that marginal cost for growth lines is equal to marginal cost for replacement lines.

Lemma 2: Under the assumption of Case 1, the equilibrium price for replacement lines is strictly smaller than the equilibrium price for growth lines.

The result follows immediately from Proposition 2 and the fact that $\overline{P}_R = \overline{P}_G$ by the assumption of Case 1.

Case 2: Assume that competition constrains profits to zero, and that $C_G = C_R = C$. In that case, it is evident that $P_R < P_G$. This follows directly from the zero profits constraint and the fact that, for any demand specification, $P_G > C$ in the *ex post* monopoly outcome. Hence, $P_R < C$.

Clearly, for profit constraints in the neighborhood of zero, the result will hold as well, by continuity.

The conditions of Cases 1 and 2 are sufficient, though not necessary, for $P_R < P_G$. When profits are bounded away from zero, the same result will hold for a variety of demand specifications in which second period demand is higher than replacement demand (generally, as long as the monopoly price does not decline too rapidly as demand grows). The result is also consistent with the result of Borenstein, Mackie-Mason, and Netz,[1] who analyze a similar problem in the context of a reputational model. They show (in a homogeneous goods model) that even if reputation effects induce a firm to choose not to

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[1] Borenstein, Severin; Mackie-Mason, Jeffrey; and Netz, Janet. "Exercising Market Power in Proprietary Aftermarkets." *Journal of Economics & Management Strategy*, Vol. 9, no. 2, (Summer 2000), pp. 157-188.

exploit its full *ex post* monopoly power, it will nevertheless set *ex post* prices above the *ex ante* prices.

Hence, the observed structure of SBC's contracts with vendors is consistent with the equilibrium price structure established in Proposition 3 and the demand structure modeled in Case 2. The vendor contracts offer differentiated prices for growth and replacement lines, with higher prices for growth lines. The model I have presented here, based on the characteristics of switch vendor contracts, explains this competitive behavior.

D. Sensitivity analysis: Growth and Replacement Demand

In this Section I analyze the sensitivity of the model with respect to the relative weighting of demand for access lines between replacement and growth lines. The motivation for the analysis is that some have argued that, in applying the TELRIC methodology, one should assume that all lines would be replacement (or new) lines. I show that if the carrier and vendor were to negotiate contracts under that condition (or any other change in the ratio of growth to replacement/new lines), the existing contract prices would not prevail because they would be unacceptable to the vendor. The prices of growth and replacement/new lines are *interdependent* through the effects of the *ex ante* competition and *ex post* monopoly, so any increase in the proportion of replacement lines will increase their price.

In order to perform the analysis, I analyze the results of the model as I increase the proportion of replacement lines while keeping the total demand for lines constant.

Let $N\ (P_R, P_G) = \theta \cdot N_R + (1-\theta) \cdot N_G(P_G) = \overline{N}$, where $\theta \in [0,1]$ is an exogenous demand parameter that shifts total line demand between replacement and growth lines, for a total fixed demand for access lines.

Proposition 4: Assuming again that $P_G'' \leq 0$ and $C_G = C_R$, as the proportion of replacement lines relative to total lines grows, the replacement line price will increase. That is, $\frac{\partial P_R^*}{\partial \theta} > 0$.

Proof: $Z(P_R^*(\theta), \overline{P}_G(\theta), \theta) = (P_R^* - C_R)\theta\, N_R + \sum_{t=1}^{T} \{(\overline{P_G} - C_G)(1-\theta)\, N_G\} \left(\frac{1}{1+r}\right)^t \equiv \pi$

by (ii) of Proposition 1.

Totally differentiating with respect to θ,

$$\frac{\partial Z}{\partial P_R^*}\frac{\partial P_R^*}{\partial \theta}d\theta + \frac{\partial Z}{\partial \overline{P}_G}\frac{\partial \overline{P}_G}{\partial \theta}d\theta \ + \frac{\partial Z}{\partial \theta}d\theta = 0.$$

By $P_G'' \leq 0$, and by the second order conditions on profit maximization, $\frac{\partial \overline{P}_G}{\partial \theta} < 0$.

Moreover, because N_R is fixed by contract, $\frac{\partial Z}{\partial P_R^*} > 0$. By examination of

$Z\left(P_R^*(\theta), \overline{P}_G(\theta), \theta\right)$,

$$\frac{\partial Z}{\partial P_G} > 0.$$

By Assumption 1,

$$\frac{\partial R}{\partial \theta} < 0.$$

Hence, $\frac{\partial P_R^*}{\partial \theta} > 0.$

Q.E.D.

Proposition 4 shows that the higher is the percentage of replacement lines relative to all access lines demanded, the higher is the price for replacement lines. Hence, if, in the extreme, SBC were to negotiate a price under the assumption that all lines would be replacement lines and no lines would be growth lines, the price for replacement lines would be higher than the price in the existing contracts. The reason is apparent: if there were no growth lines there would be no *ex post* monopoly problem. Hence, there would be no need for unduly low replacement line prices to "make up for" the high anticipated growth prices.

IV. Single price equivalency

I have shown that the replacement and growth prices are necessarily interrelated and each depends on the relative quantities demanded of the two types of lines expected going forward. In this Section, I show that a single price can be defined (and calculated) that collapses the multi-tiered price structure in the contract to a single number. This is the price that vendors *would* offer if they were constrained to offer a single price for both replacement and growth lines, and could avoid the *ex post* monopoly problem by committing irrevocably to not renegotiating the growth price later. In that case, the price it would charge would generate the same level of expected profits for the vendor (π), taking into account the profit constraints imposed by competition from other vendors.

Let $P^* = \left(P_R^*, \overline{P}_G\right)$ be defined as the vendor solution to Program 1. I identified in Proposition 1 the unique set of prices that satisfies subgame perfection and proved in Proposition 3 that the growth price will exceed the replacement price, given the *ex post* monopoly problem. I show in this section that there always exists a set of prices such that $P_R = P_G$, where Z evaluated at these prices and at the equilibrium level of demand $N_i, i = G, R$ equals Z^*. Of course, these prices cannot be subgame perfect, by Proposition 3.

Proposition 5: There always exists a single price P such that P applies to both replacement and growth lines, and $Z(P) = R^*(\{P^*\})$, evaluated at the equilibrium demand.

Proof: The price P at which the vendor would earn the same profits as under the equilibrium contract solves

$$\sum_{t=0}^{T}\{P\ (N_{Rt}+N_{Gt})-(C_R N_{Rt}+C_G N_{Gt})\}\left(\frac{1}{1+r}\right)^t =$$

$$\sum_{t=o}^{T}\{(P_R-C_R)N_{Rt}+(P_G-C_G)N_{Gt}\}\left(\frac{1}{1+r}\right)^t.$$

Solving for P we have,

$$P\ =\frac{\sum_{t=0}^{T}\left\{(P_R N_{Rt}+P_G N_{Gt})\left(\frac{1}{1+r}\right)^t\right\}}{\sum_{t=0}^{T}\left\{(N_{Rt}+N_{Gt})\left(\frac{1}{1+r}\right)^t\right\}}.$$

The price P is the TELRIC price implied by the vendor contracts. This is the unique price that reflects the discounted present value of profits that the vendors are able to capture given the state of competition in the vendor market. The TELRIC price is the single price equivalent to the two-price-structure prices that are mandated by the *ex post* monopoly problem inherent in the fact that switch modules are not interchangeable across vendors once a switch is installed. The single-price-equivalent price is, therefore, the price that would be expected to prevail if the buyer were to negotiate a contract in which all lines were replacement lines.

The equations defined in Proposition 5 may be used to compute a single-price equivalent when more than two prices are melded together. As discussed in Section II, some vendor contracts also include a price for "new lines." From the end user's perspective, new lines provide the exact same service as replacement lines or growth lines. Similarly, some vendor contracts include buy-outs of previously installed capacity, whereby a certain number of lines are sold for a lump-sum price.[2]

While new lines are identical to replacement or growth lines from the user's perspective, they are similar to replacement lines from an economic standpoint. The reason is that the vendors have no *ex post* monopoly power with respect to new lines. Vendors are not in the position of charging monopoly prices for these lines, but rather will compete on the new line price in order to win contracts. Once these new switches are installed, however, the vendor has *ex post* monopoly power over growth lines added to that switch. Hence, for the same reasons demonstrated in Section III, new lines should be expected to be priced below growth prices.[3]

The single-price equivalent calculation gives the average price per line that would yield the same expected discounted profits to the vendor as the current multi-tiered pricing structure. This is true whether there are two line-types, as in Proposition 5, or more.

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[2] These "buy-out" costs were charged by the vendors as part of the transition costs from the former Ameritech Partners In Provisioning ("PIP") contracts to the new SBC-wide contracts. These buyouts represent the purchase price to SBC for additional lines installed by the vendors on SBC switches under the old PIP contracts. As such, SBC is required to purchase this particular quantity of lines; no more and no less.

[3] This theory does not predict that new and replacement lines will have the same price as each other however; in fact, they typically do not. New prices are generally higher than replacement prices in contracts in which both appear. This is consistent with the fact that it is probably less costly to replace an analog switch with a new switch than to install a new switch in a new location. In the former case, the electricity, building, and other infrastructure are already in place while in the latter, they are not. In addition, replacing an analog switch has the benefit of saving the costs of maintaining outmoded and obsolete equipment.

Assume that the set of prices $\{P_R, P_G, P_N, P_B\}$ contains the average per-line prices for replacement, growth, new, and buyout lines, respectively, that the set of quantities $\{N_R, N_G, N_N, N_B\}$represents the number of replacement, growth, new, and buyout lines that will be purchased, and that $\{C_R, C_G, C_N, C_B\}$ represents the average per-line cost of replacement, growth, new, and buyout lines. Assume further that P^* is the single-price equivalent.

The single-price equivalent P^* under which the vendor would earn the same expected profits as under the multi-tiered vendor pricing solution solves the following equation:

$$\sum_{t=0}^{T}\{P^*(N_{Rt}+N_{Gt}+N_{Nt}+N_{Bt})-(C_R N_{Rt}+C_G N_{Gt}+C_N N_{Nt}+C_B N_{Bt})\}\left(\frac{1}{1+r}\right)^t =$$

$$\sum_{t=o}^{T}\{(P_R-C_R)N_{Rt}+(P_G-C_G)N_{Gt}+((P_N-C_N)N_{Nt}+(P_B-C_B)N_{Bt}\}\left(\frac{1}{1+r}\right)^t .$$

Solving for P^* yields:

$$P^* = \frac{\sum_{t=0}^{T}\left\{(P_R N_{Rt}+P_G N_{Gt}+P_N N_{Nt}+P_B N_{Bt})\left(\frac{1}{1+r}\right)^t\right\}}{\sum_{t=0}^{T}\left\{(N_{Rt}+N_{Gt}+N_{Nt}+N_{Bt})\left(\frac{1}{1+r}\right)^t\right\}} .$$

V. Conclusion

I have demonstrated that although the lock-in effect inherent in switching technologies necessarily gives rise to multi-part equilibrium pricing contracts, these contract prices can be expressed as uniform prices that generate the same expected vendor revenues and expected vendor profits. These uniform prices are a function of replacement, new, and growth demand, but not a function of the costs of providing replacement and growth lines. The uniform (single price equivalent) prices derived in Section IV form the basis for certain of SBC's TELRIC prices.